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SUPPLEMENTARY MATERIAL

Conservation of the Ethiopian church forests: threats, opportunities and implications for their management

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Fig. S1 Typical landscape in the northern highlands of Ethiopia

Fig. S2 Church forest C249 in the northern highlands of Ethiopia

Fig. S3 Typical landscape in the central highlands of Ethiopia

Fig. S4 Church forest C578 in the central highlands of Ethiopia

Fig. S5 Church forest digitization process

Fig. S6 Deforestation frontier in the central highlands of Ethiopia

Table S1 Indicator species for woody species communities of church forests

Table S2 Spearman rank correlations between NMDS scores and environmental variables

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Fig. S1 Typical landscape in the northern highlands of Ethiopia (14° 0.8'N 38° 46.1'E). Image © 2014 CNES/Astrium by way of Google Earth. Eye altitude 10 km, surface area approximately 9×5 km².

Fig. S2 Church forest C249 in the northern highlands of Ethiopia (14° 0.8'N 38° 46.1'E), located in the center of Fig. S1. Image © 2014 CNES/Astrium by way of Google Earth. Eye altitude 3 km, distance from church to southern edge 370 m. Note irregular shape and highly variable forest quality within the patch.

Fig. S3 Typical landscape in the central highlands of Ethiopia (11° 54.8'N 38° 3.0'E). Image © 2014 CNES/Astrium by way of Google Earth. Eye altitude 10 km, surface area approximately 9×5 km². The average distance between the three church forests on the left of the image is 2.1 km.

Fig. S4 Church forest C578 in the central highlands of Ethiopia (11° 54.8'N 38° 3.0'E) located in the center of Fig. S3. Image © 2014 CNES/Astrium by way of Google Earth. Eye altitude 3 km, patch radius 120 m. Note regular shape, central location of the church and almost uniform quality throughout the patch.

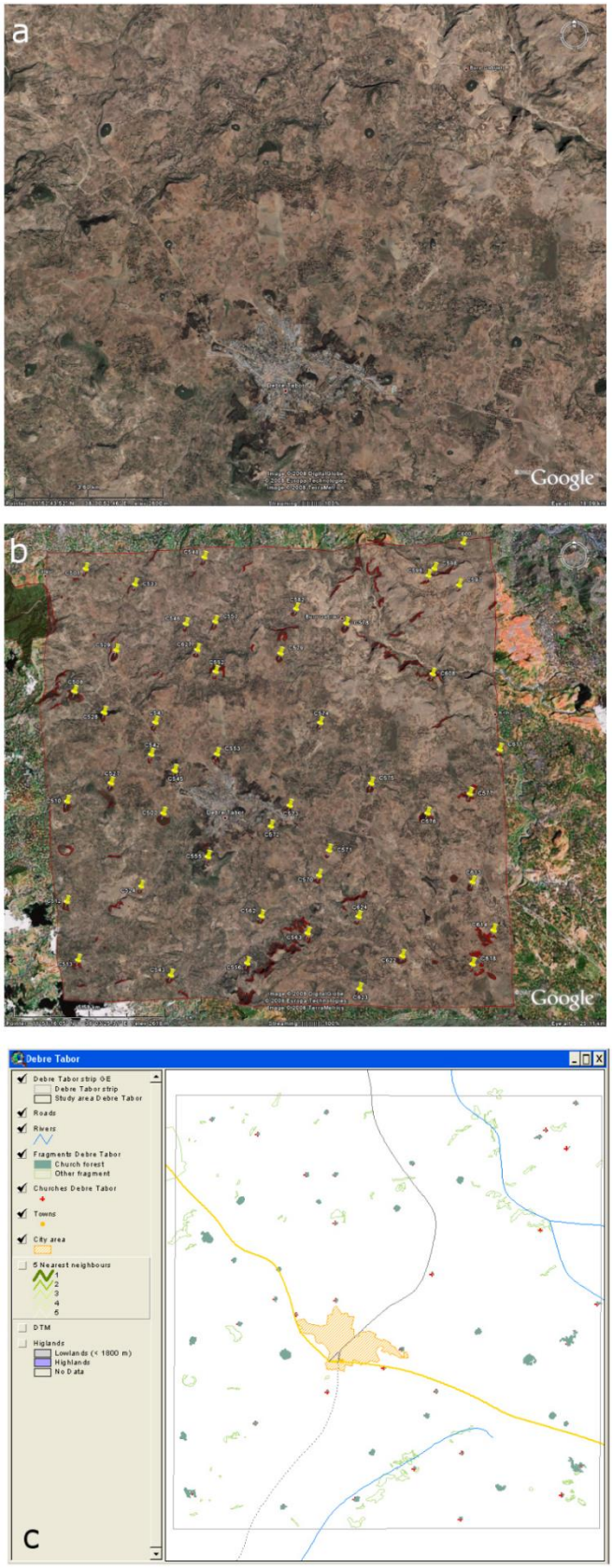

Fig. S5 High spatial resolution images in Google Earth (a) were digitized on screen (b) and via KML format imported into ArcView GIS (c). Digitized boundaries are not part of the Google Earth source material but an interpretation of the authors and therefore do not inherit any copyright from the source material.

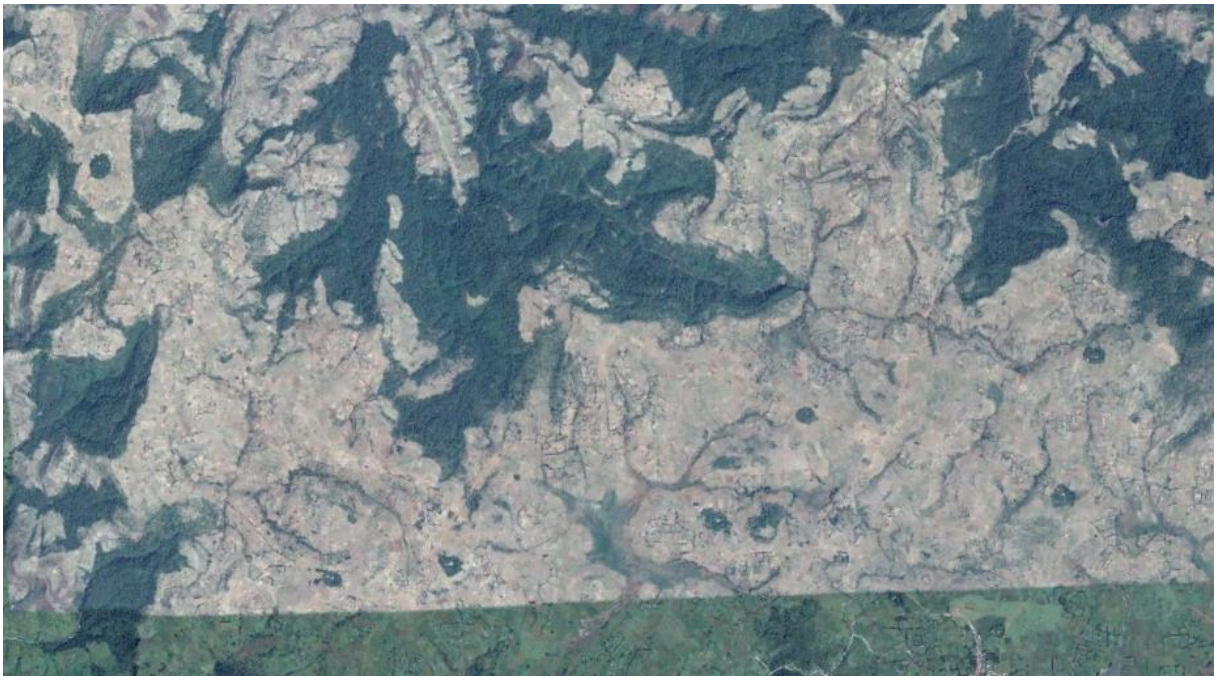

Fig. S6 Deforestation frontier in the central highlands of Ethiopia (10° 50.9'N 36° 33.6'E). Image © 2014 CNES/Astrium by way of Google Earth. Eye altitude 15 km, east-west extent ~17 km, image date 03/01/2014. In the deforested landscape in the southern half of the image forest vegetation only persists in church forests, while in the northern half larger blocks of forest are still present (image date 03/01/2014). Note the almost grid-like pattern of church forests in the south and the process of isolation ongoing in the upper left corner of the image.

Table S1

Indicator species for woody species communities of church forests in the dry evergreen Afromontane forest and grassland complex zone of Ethiopia produced by cluster and indicator species analysis.

Dry single-dominant Afromontane forest				Undifferentiated Afromontane forest			
Olea-Acacia (*N*=10)		*Juniperus-Olea* (*N*=22)		*Juniperus* (*N*=21)		*Juniperus-Afrocarpus* (*N*=23)	
Rhus natalensis[S]	86 (<0.001)	*Cordia africana*[T]	25 (0.015)	*Vernonia myriantha*[S]	67 (<0.001)	*Vernonia auriculifera*[S]	66 (<0.001)
Euclea racemosa[S]	50 (<0.001)	*Dodonaea sp.*[S]	25 (0.05)	*Urera hypselodendron*[S]	57 (<0.001)	*Allophylus abyssinicus*[T]	55 (<0.001)
Cassia sp.[S]	50 (<0.001)	*Ficus vasta*[T]	23 (0.039)	*Osyris sp.*[S]	45 (<0.001)	*Bersama abyssinica*[T]	51 (<0.001)
Psiadia punctulata[T]	30 (<0.001)	*Rydingia integrifolia*[S]	19 (0.036)	*Canthium oligocarpum*[S]	45 (<0.001)	*Dovyalis abyssinica*[T]	46 (<0.001)
Combretum collinum[T]	30 (<0.001)	*Acacia polyacantha*[T]	19 (0.042)	*Clausena anisata*[T]	41 (<0.001)	*Jasminum stans*[S]	44 (<0.001)
Leucas sp.[S]	28 (<0.001)	*Rhus pyroides*[S]	18 (0.026)	*Buddleja polystachya*[T]	40 (0.001)	*Euphorbia candelabrum*[T]	37 (<0.001)
Faidherbia albida[T]	26 (<0.001)			*Euphorbia abyssinica*[T]	38 (0.001)	*Ekebergia capensis*[T]	37 (0.002)
Acacia seyal[T]	14 (0.044)			*Dombeya torrida*[T]	36 (<0.001)	*Pavetta spp.*[S]	34 (0.002)
				Rosa abyssinica[S]	35 (0.004)	*Maytenus obscura*[T]	32 (0.002)
				Maytenus arbutifolia[T]	35 (0.009)	*Maytenus gracilipes*[T]	31 (0.002)
				Schrebera alata[T]	34 (0.001)	*Vepris nobilis*[S]	28 (0.004)
				Juniperus procera[T]	32 (0.020)	*Afrocarpus falcatus*[T]	28 (0.005)
				Albizia schimperiana[T]	31 (0.003)	*Vernonia leopoldii*[S]	27 (0.003)
				Schefflera abyssinica[T]	30 (0.001)	*Blumea elatior*[S]	27 (0.009)
				Erythrina brucei[T]	28 (0.006)	*Brucea antidysenterica*[T]	27 (0.022)

Ritchiea albersii[S]	28 (0.005)	*Maesa lanceolata*[S]	25 (0.015)
Teclea nobilis[S]	28 (0.014)	*Ficus sur*[T]	24 (0.018)
Rhus glutinosa[S]	28 (0.023)	*Discopodium penninervium*[S]	24 (0.018)
Syzygium guineense[T]	25 (0.004)	*Galiniera saxifraga*[S]	23 (0.020)
Hypericum revolutum[T]	24 (0.002)	*Euphorbia depauperata*[T]	22 (0.019)
Combretum molle[T]	22 (0.012)	*Albizia gummifera*[T]	22 (0.019)
Rhus vulgaris[S]	22 (0.016)	*Rubus steudneri*[S]	22 (0.020)
Millettia ferruginea[T]	21 (0.042)	*Rytigynia neglecta*[S]	22 (0.022)
Ficus ovata[T]	19 (0.028)	*Dracaena afromontana*[T]	18 (0.043)
		Maytenus undata[T]	17 (0.042)

The indicator values range from zero (no indication) to 100 (perfect indication). *p*-values (in parantheses) are calculated from a Monte Carlo permutation test for each species. Superscripts indicate life forms: trees (T) and shrubs (S). Only species with a significant indicator value ($p < 0.05$) are shown.

Table S2

Spearman rank correlations between NMDS scores and environmental variables for church forests in the dry evergreen Afromontane forest and grassland complex zone of Ethiopia (N = 76).

	NMDS1 (R^2 = 0.380)		NMDS2 (R^2 = 0.263)	
	R_S	p	R_S	p
Degrees north	-0.568	< 0.001*	0.058	0.617
Degrees east	-0.465	< 0.001*	0.382	0.001*
Elevation	0.294	0.010	0.679	< 0.001*
Mean annual precipitation	0.638	< 0.001*	0.080	0.494
Distance to rivers	0.203	0.079	0.036	0.755
Distance to roads	-0.063	0.586	0.196	0.089
Distance to towns	-0.416	< 0.001*	0.022	0.847
Urban and rural population	0.380	0.001*	-0.016	0.888
Slope	-0.061	0.603	0.171	0.139
Heat load	0.070	0.549	0.160	0.893

*Spearman rank correlation coefficients R_S between NMDS scores and environmental variables need to be evaluated against a corrected $\alpha_{corr} = 0.005$ to assure an overall significance of $\alpha = 0.05$ (Bonferroni correction for ten tests).